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You may cite this version as: Young, Michael W. and Adderley, Paul, 2007. Here is Now and There the Sound of the Land: 'Ground-breaking'. MutaMorphosis: Challenging Arts and Sciences Conference Proceedings , p. 1. [Article]: Goldsmiths Research Online.

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HERE IS NOW AND THERE THE SOUND OF THE LAND: *GROUND-BREAKING.*

SCIENTIFIC AND SONIC PERCEPTIONS OF THE AFRICAN SAHEL

Societies are often required to react to extreme events that arise through either anthropogenic or natural processes. Such extremity might be measured is in terms of its immediacy and intensity; it demands comprehension against understood norms. For example, our present-day debate on future climatic change is driven by scientific assertion, reinforced by evidence gathered from both instrument and indirect proxy measurements, whilst the varying societal responses are predicated by everyday cultural experiences. In contrast, places considered to offer experiences at the boundaries of or outside the everyday, e.g. hot and cold deserts, provide a different conception of *extreme*. In this conception, change and the rates of change typically lack context, validation and position within everyday norms. Consequently, it is within such surroundings that the greatest tension occurs between the perception of place and rates of change. While the methodologies of science and art practice are often respectively considered positivistic and non-rational, both are in fact able to investigate the *extreme* in this context. Whether or not such characterisations are legitimate, the obvious epistemological differences both illuminate and problematise our understanding. In this paper we describe a real-time generative installation commissioned from the authors by the UK Research Councils called *Ground-breaking: Extreme Landscapes in Grains and Pixels* that attempts to explore and test these differences[1]. Further examples are available at http://www.ground-breaking.net.

This work offers context and potential validation about change and the rate of change of an extreme environment: this is evidenced through scientific analysis of landscapes and soils and is translated, in a process of critical evaluation, to create an audio-visual installation. The installation seeks to convey cultural imprints left by societal responses to change experienced in a marginalised area, the African Sahel. By considering a landscape that is both extreme and has long-standing cultural activity, a narrative is developed. To borrow Barthes's terminology (Barthes, 1977), the data from scientific analysis provide *functions* to the narrative; they are indices to the landscape and to human conditions. These data also connote *actions* that may be anthropogenic or environmental (such as changes in land management, house building, flooding and desertization). A narrative emerges from the exploration of these data, in which a sequence of actions is deduced from functional descriptions of physical objects, which are in turn offered for evaluation and exploration in sonic and visual forms.

CONTEXT AND INVESTIGATION

The fertility of soil is fundamental to the long-term sustainability of human societies and is a source of, and sink for, materials used to sustain human existence. Soils may retain the imprint of cultural activities, presenting an opportunity to examine how past societies managed their surrounding landscapes. Soils can act as a record of past cultural activities; the examination of such soils – cultural soils – is a major element in the *Ground-breaking* installation.

The soil materials referred to by the installation were sampled from the West African Sahel at a village called Tiwa located in the lacustrine plain of Lake Chad in Northern Nigeria (Adderley, et al., 2004). This region has experienced

[1] First shown at National Museum of Scotland, Edinburgh 2007. Supported by Research Councils UK, NSW2007 Award

extremes of flooding and drought throughout history that may have displaced the human population. The village has dwellings constructed from mud-brick and thatch, surrounded by fields. Samples were taken from a pit dug close to the village. This area is subject to intense land management and receives cultural debris washed-in by seasonal rains. The materials were sampled intact with the spatial organisation of the soil maintained through processing and examination in the laboratory. The soils were found to span a 10,000 year period that includes the onset of human settlement in the Lake Chad plain c. 4000 years ago (Connah, 1981). For the *Ground-breaking* installation these materials were analysed to produce data streams suitable to cross-disciplinary interpretation. An examination of large areas of the samples allows a virtual exploration of microscale features. By using the latest digital image-analysis methodologies, a quantitative examination of the materials identifies objects that provide discrete cultural signals. These objects can then be classified and spatially related and in turn be used to develop a sonic narrative drawing upon both the measurements and their interpretation as cultural signifiers.

To allow microscopic viewing, the soil materials were treated to produce glass-mounted thin-section samples. The samples were dried, impregnated with resin, mounted, ground and polished to a uniform thickness of 30 μm. At this thickness grains of quartz mineral are translucent. The thin-section samples were observed with a microscope and images captured with a sequence of different illumination methods, each producing a different resultant image. For example, the oblique incident reflected light image typically shows dark images with colours that can be interpreted as related to cultural activities; specifically burnt materials, such as pieces of fired clay and partially combusted fuel materials, show clearly as ruby reds and orange colours.

From eight microscope slides a total of thirty-two areas were analysed. For each sample area a large-scale calibrated image was made, repeated for all four illumination methods. These images were examined using image-analysis techniques (Russ, 2006; Adderley et al., 2002), each group of objects representing the imprint of a different cultural event: construction and destruction of buildings, soil disturbances such as cultivation and periods of flooding. Each object in the image was identified and its size, shape and location analysed. With the object defined as a mass of contiguous pixels that satisfy the segmentation criteria of specific colour properties, the object's area is given by counting the number pixels whilst the outer edge of the mass of pixels is the object perimeter. Holes are identified as pixels outside the segmentation criteria yet bounded by those that are. Shape was estimated by measuring parallel tangents – Feret measurements – at 360 positions around each object (Russ, 2006). The fractal dimension of each object, a derived measure of shape, was calculated from the area and perimeter relationship (Mandelbrot, 1977). By considering the centre of the object as the point with the maximum distance from any point on the perimeter, a set of co-ordinates for each object within an image can be determined. There is therefore a data set for every identified object comprising {x,y} spatial coordinates and a descriptive list; object area, perimeter, count of the holes in the object, Feret mean, fractal dimension and colour hue, saturation and intensity. These and the 10,000 year temporal data form the precursors for the implementation and structure of the installation.

IMPLEMENTATION OF THE *GROUND-BREAKING* INSTALLATION

The macrostructure of the installation is guided by a master clock that represents the 10,000 years. The equivalent time interval executed by the installation system varies on each cycle, which denotes interpolated data describing the lake-level of Lake Chad at decadal intervals. The levels are indicative of three states; flood, drought or human-populated. These data are interpreted as a probability function that influences the generative processes of the installation. Adaptive probability systems have been applied in other recent work by Young (2007).

The visual component comprises a library of on-site photographs and the thin-section images of soil samples. At irregular time intervals a thin section is selected and images, along with soil data, are loaded. The choice is randomised, restricted to the time period indicated by the current position of the master clock. Images are deployed in cross-fading combinations to allow for complementary perspectives of colour and detail. Real-time visual behaviours are related to the lake-level state: drought (minor colouration effects), flood (flowing progression between data points,) and human population settlement (onsite photographic material actively interspersed). Sound materials are controlled similarly, such that the most clearly referential sounds (i.e. environmental, voices, music) are more likely when relevant to the historical scale. Audio material is generated from the soil data' each object's descriptors (area, perimeter, Feret, etc..) are mapped to the sound synthesis algorithm. as long as the current image selection is in view.

The generation of sound from non-musical data is well established (Scaletti, 1994). Pre-existing wave functions are easily susceptible to sonfication, by a direct mapping of function to synthesis. This approach can be contrasted to higher level mapping strategies, in which an input parameter set is made congruent with the requirements of a specific sound generating system (Hermann & Ritter, 1999). Parameter mapping strategies have been classified as one-to-one, divergent or convergent (Hunt & Wanderley, 2002), indicating the possibilities for data to be directly translated, directed to a multiplicity of parameters, or condensed to fewer dimensions. Designer intervention – whether intentional or not – is common in this mapping process. In all these cases, the broad aim of sonification is to render complex data susceptible to analysis. A common question arises from the absence of time information in the data itself, and the consequent need for data to be linearised in time as a stream of discrete events. Given that temporalisation *is*, in effect, sonification, some form of creative decision-making is unavoidable, and must to some extent be predicated on the desired outcome of the investigation.

In *Ground-breaking*, the mapping of data to sound parameters is arbitrary but consistent in any one cycle of the 10,000 year history. For each iteration of the master cycle, the mapping is assigned autonomously by the system with no creative intervention from a user. There are seven data parameters and over twenty sound synthesis parameters, so this reshuffling is decisive in pre-determining the vocabulary and behaviour of sounds. Two synthesis techniques are employed; subtractive synthesis (multi-band filtered noise) and granular synthesis (or granular reconstruction, the production of extensive and timbrally-rich sound events by the proliferation of tiny sonic fragments). Granular methods offer the possibility of clear sonic reference, and more abstract material, depending on the content, duration and processing of individual grains. Sonic parameters include the frequency content, bandwidth and harmonicity of filter banks, the size, content, amplitude, post-processing of grains. Grain content is critical: this is obtained from a library of recorded sounds stored by the system, tagged with descriptors denoting their referential content (such as water, work, environment, human voice, music) and sonic character (loudness brightness, roughness, pitch-noise). The tags are assigned as sound parameters, so sound sources are read into the granular synthesiser as a basis for subsequent events. The complete process is summarized in Figure-1.

Our purpose is not direct sonification but non-rational exploration and narration. Sonic – and visual – production is not intended as a proxy for the actual data There is a new emergent narrative that references data both directly and obliquely. This narrative seeks a structural and syntactical relationship that is consistent and, in theory, comprehensible. Returning to Barthes, the *narrative* constructed in *Ground-breaking* is the result of a stochastic exploration of the soil data sets as cultural indices. The narration is both cyclical and open-ended; because periodic techniques are combined with probability functions, no cycle is repeated. The exploration is in part randomly driven, but, given that the data can be parameterised as a time-based (i.e. rhythmical) function, the narrative is also self-referential. The data sets have a *functional* role in the narrative; they are also a mode of description of the material objects that connotes *actions*. In this case, actions can only be deduced from the description, and may be human or environmental (such as interventions in land maintenance, firing bricks, flooding activity). So, a narrative emerges from the exploration of a data space, in which a sequence of actions can be deduced from functional descriptions of physical objects.

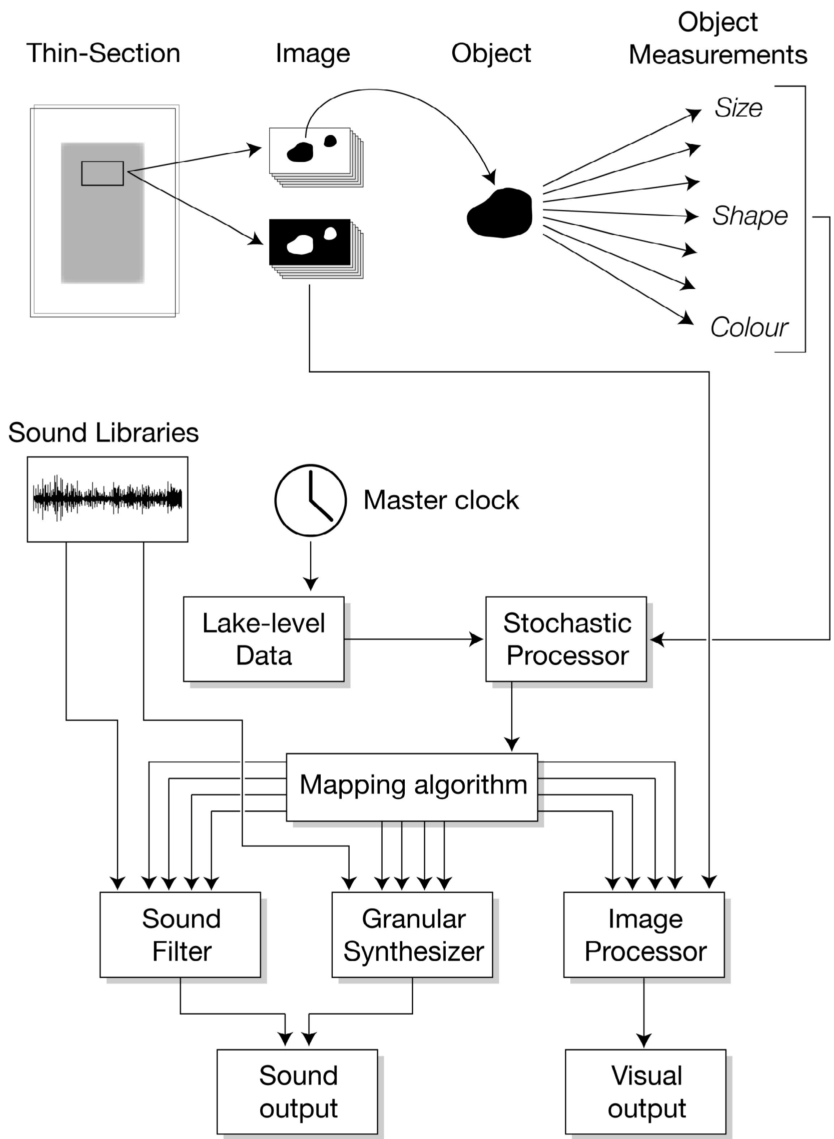

Figure-1. Schema of *Ground-breaking* installation; from soil thin-section to sound and visual projection s .

CONCLUSION

The *Ground-breaking* installation was commissioned to raise awareness of the scientific aspects of how people have coped with extreme modifications, regardless of causation, of the environment of the African Sahel. The work has problematised notions of data representation, such that it offers a critique of data-sets rather than a simple audification. In doing so it has attempted to breach the barriers presented by different temporal and spatial scales: between landscape and the production of artefacts, between the scientific analysis of artefacts and their manufacture, between the perception of visual and sonified representations, and between micro-scale information and macro-scale evidence of extreme climatic change. Direct deduction of the human processes or environmental events is not explicitly sought such that the installation remains an unresolved generative work; in this form it promotes the audience towards a liminal space, an understanding of place and of rates of change.

The narrative developed explores a data space which contains as set of deduced actions from functional descriptions of physical objects; this has revealed the possibility that a yet more detailed data analysis and deeper data space exploration can produce further novel insights into the nature of the cultural imprints held by the soil. This also highlights the transferability of the meta-constructs of the narrative to other domains including other geographical environments with other cultural imprints.

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